

FORM PTO-1390  
(REV 5-93)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

**TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING  
A FILING UNDER 35 U.S.C. 371**

381NT/49741

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)

09/763972

INTERNATIONAL APPLICATION NO.  
PCT/IP00/00374INTERNATIONAL FILING DATE  
26 January 2000

PRIORITY DATE CLAIMED

TITLE OF INVENTION

ELECTROMAGNETIC FUEL INJECTOR

APPLICANT(S) FOR DO/EO/US

Kiyotaka OGURA, Atsushi SEKINE, Eiichi KUBOTA, Masahumi NAKANO, Keiichi IIRAKI, Noriyuki MAEKAWA, Mizuho YOKOYAMA,  
Yoshiyuki TANABE, Hiromasa KUBO, Tooru ISHIKAWA

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
  - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☒ has been transmitted by the International Bureau
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (unexecuted).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Item 11. to 16. below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.  
☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
  - a. 5 sheets of formal drawings showing Figs. 1-3, 4a-4c, 5a-5b



23911

PATENT TRADEMARK OFFICE

U.S. APPLICATION NO (if known, see 37 CFR 1.5)		INTERNATIONAL APPLICATION NO		ATTORNEY'S DOCKET NUMBER	
09/763972		PCT/JP00/00374		381NT/49741	
17. [X] The following fees are submitted:				CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)):					
Search Report has been prepared by the EPO or JPO ..... \$860.00					
International preliminary examination fee paid to USPTO (37 CFR 1.482) ... \$690.00					
No international preliminary examination fee paid to USPTO (37 CFR 1.482)					
but international search fee paid to USPTO (37 CFR 1.445(a)(2)) ..... \$710.00					
Neither international preliminary examination fee (37 CFR 1.482) nor					
international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... \$1000.00					
International preliminary examination fee paid to USPTO (37 CFR 1.482)					
and all claims satisfied provisions of PCT Article 33(2)-(4) ..... \$100.00					
ENTER APPROPRIATE BASIC FEE AMOUNT =				\$1000.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than [ ] 20 [X] 30				\$130.00	
months from the earliest claimed priority date (37 CFR 1.492(e))					
Claims	Number Filed	Number Extra	Rate		
Total Claims	19 - 20 =	0	X \$18.00	\$	
Independent Claims	8 - 3 =	5	X \$80.00	\$400.00	
Multiple dependent claims(s) (if applicable)			+ \$270.00	\$	
TOTAL OF ABOVE CALCULATIONS =				\$1530.00	
Applicant claims Small Entity Status (See 37 CFR §1.27) [ ] yes [ ] no.				\$	
Reduction by 1/2 for filing by small entity, if applicable.					
SUBTOTAL =				\$1530.00	
Processing fee of \$130.00 for furnishing the English translation later than [ ] 20 [ ] 30				\$	
months from the earliest claimed priority date (37 CFR 1.492(f)).					
TOTAL NATIONAL FEE =				\$1530.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be				\$	
accompanied by an appropriate cover sheet (37 CFR 3.28,3.31). \$40.00 per property +					
TOTAL FEE ENCLOSED =				\$1530.00	
				Amount to be:	\$
				refunded	
				charged	\$
a. [ X ] A check in the amount of \$1530.00 for the filing fee is enclosed.					
b. [ ] Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A					
duplicate copy of this sheet is enclosed.					
c. [ X ] The Commissioner is hereby authorized to charge any additional fees, which may be required, or credit any					
overpayment to Deposit Account No. <u>05-1323</u> . A duplicate copy of this sheet is enclosed.					
NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or					
(b)) must be filed and granted to restore the application to pending status.					
SEND ALL CORRESPONDENCE TO:					
Evenson, McKeown, Edwards & Lenahan, P.L.L.C.					
1200 G Street, N.W., Suite 700					
Washington, D.C. 20005					
Tel. No. (202) 628-8800					
Fax No. (202) 628-8844					
				SIGNATURE	
				Jeffrey D. Sanok	
				NAME	
				32,169	
				REGISTRATION NUMBER	
				February 28, 2001	
				DATE	
				JDS:pc	

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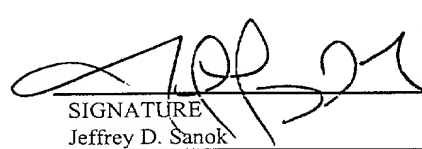
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**23911**

PATENT TRADEMARK OFFICE

U.S. APPLICATION NO. <b>09/763972</b>		INTERNATIONAL APPLICATION NO. PCT/JP00/00374		ATTORNEY'S DOCKET NUMBER 381NT/49741	
17. <input checked="" type="checkbox"/> The following fees are submitted: Basic National Fee (37 CFR 1.492(a)(1)-(5)):  Search Report has been prepared by the EPO or JPO ..... \$860.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) ... \$690.00 No international preliminary examination fee paid to USPTO (37 CFR 1.482)  but international search fee paid to USPTO (37 CFR 1.445(a)(2) ..... \$710.00 Neither international preliminary examination fee (37 CFR 1.482) nor  international search fee (37CFR 1.445(a)(2) paid to USPTO ..... \$ 1000.00 International preliminary examination fee paid to USPTO (37 CFR 1.482)  and all claims satisfied provisions of PCT Article 33(2)-(4) ..... \$100.00  <b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b> \$1000.00				CALCULATIONS	PTO USE ONLY
Surcharge of \$130.00 for furnishing the oath or declaration later than [ ] 20 <input checked="" type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$ 130.00	
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<b>TOTAL FEE ENCLOSED =</b>				\$1530.00	
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SEND ALL CORRESPONDENCE TO: Evenson, McKeown, Edwards & Lenahan, P.L.L.C. 1200 G Street, N.W., Suite 700 Washington, D.C. 20005 Tel. No. (202) 628-8800 Fax No. (202) 628-8844					
				 SIGNATURE Jeffrey D. Sanok	
				NAME 32,169	
				REGISTRATION NUMBER February 28, 2001	
				DATE	
JDS:pc					

09/763972

JCO3 Rec'd PCT/PTC 28 FEB 2001

Attorney Docket: 381NT/49741  
PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: KİYOTAKA OGURA ET AL.

Serial No.: NOT YET ASSIGNED PCT NO. PCT/JP00/00374

Filed: FEBRUARY 28, 2001

Title: ELECTROMAGNETIC FUEL INJECTOR

PRELIMINARY AMENDMENT

Box PCT  
Commissioner for Patents  
Washington, D.C. 20231

Sir:

Please enter the following amendments to the claims and abstract prior to the examination of the application.

IN THE CLAIMS:

Please amend claim 10 as follows:

(A copy of the marked-up version of amended claim 10 is attached as an appendix to this Preliminary Amendment).

10. An electromagnetic fuel injector according to claim 8, characterized in that a guide groove for guiding the fuel to the outer circumference of the fuel swirler is formed between the upper end surface of the fuel swirler and the receiving surface of the nozzle body for receiving the upper end surface of the fuel swirler.

Serial No.

Please add new claims 18 and 19 as follows:

--18. An electromagnetic fuel injector according to claim 9, characterized in that a guide groove for guiding the fuel to the outer circumference of the fuel swirler is formed between the upper end surface of the fuel swirler and the receiving surface of the nozzle body for receiving the upper end surface of the fuel swirler.

19. An electromagnetic fuel injector according to claim 18, characterized in that the guide groove is formed at the upper end surface of the fuel swirler and/or the receiving surface of the nozzle body.

IN THE ABSTRACT:

Please substitute the new Abstract of the Disclosure submitted herewith on a separate page for the original Abstract presently in the application.

REMARKS

Entry of the amendments to the claims and abstract before examination of the application is respectfully requested.

If there are any questions regarding this Preliminary Amendment or this application in general, a telephone call to the


Serial No.

undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

It is respectfully requested that, if necessary to effect a timely response, this paper be considered as a Petition for an Extension of Time sufficient to effect a timely response and shortages in other fees, be charged, or any overpayment in fees be credited, to the Account of Evenson, McKeown, Edwards & Lenahan, P.L.L.C., Deposit Account No. 05-1323 (Docket #381NT/49741).

Respectfully submitted,

February 28, 2001

  
Jeffrey D. Sanok  
Registration No. 32,169

EVENSON, MCKEOWN, EDWARDS  
& LENAHA, P.L.L.C.  
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JDS:pc

--ABSTRACT OF THE DISCLOSURE

A fuel swirler positioned upstream of an injection orifice is disposed at the tip of a nozzle body in a fuel injector, in which the fixed core and the nozzle body are coupled to each other via a non-magnetic cylindrical seal ring press-fitted and welded to the outer circumference of one end on the nozzle body side of the fixed core and the inner circumference of one end of the nozzle body. The inner circumference of the fuel swirler and the inner circumference of the seal ring function serve as a guide for slidably guiding a stroke movement of the needle. The fuel swirler is held between the receiving surface of the nozzle body and the orifice plate, thus defining an annular fuel passage between the outer circumference of the fuel swirler and the inner circumference of the nozzle body, so that fuel flows into a passage groove formed at the lower end surface of the fuel swirler via the annular fuel passage. A mass movable in an axial direction independently of the needle is interposed between the return spring and the needle, and a plate spring is interposed between the mass and the needle.--

Serial No.

APPENDIX TO PRELIMINARY AMENDMENT

(Marked-up version of amended claims)

Please amend claim 10 as follows:

10. (Amended) An electromagnetic fuel injector according to claim 8 [or claim 9], characterized in that a guide groove for guiding the fuel to the outer circumference of the fuel swirler is formed between the upper end surface of the fuel swirler and the receiving surface of the nozzle body for receiving the upper end surface of the fuel swirler.

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JCO3 Rec'd PCT/PTO

09/763972

28 FEB 2001

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## Electromagnetic Fuel Injector

### BACKGROUND OF THE INVENTION

#### Technical Field

The present invention relates to an electromagnetic fuel injector (injection valve) for an internal combustion engine.

#### Background Art

There has been conventionally used an electromagnetic fuel injector which is driven in response to an electric signal output from an engine control unit in an internal combustion engine for an automobile or the like.

This type of fuel injector is configured such that an electromagnetic coil and a yoke are arranged around a hollow cylindrical fixed core. And a nozzle body containing a movable element (hereinafter call "needle") with a valve element is fixed to the lower portion of the yoke, so that the needle is urged toward a valve seat by the force of a return spring.

A two-point support guide system is generally used for the needle in order to achieve the stability of a stroke movement. For example, as disclosed in Japanese Patent Laid-Open No. Hei 11-200993, in the case where the movable element is a needle valve, the tip of the needle valve is slidably guided on the inner circumference of a

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fuel swirler housed inside a nozzle body. And as to another point, a large-diameter portion functioning as a guide surface on a movable side is formed in the needle valve, to be thus slidably guided on the inner circumference of the nozzle body. A similar two-point support guide system is used for a needle configured by integrally coupling a ball and a rod which serve as a valve element.

In recent years, a fuel injector for directly injecting fuel into a cylinder in an internal combustion engine has been put to practical use also in a gasoline engine.

In the direct injection type of fuel injector, there has been proposed a long nozzle injector in which a nozzle body disposed under a yoke is slenderly elongated. In fixing such a long nozzle injector to a cylinder head, only the slender nozzle body occupying little space is placed on the cylinder head. And in the injector, a large-diameter body consisting of a yoke, a connector mold and the like can be provided apart from other parts and the cylinder head without any interference. Therefore, in the case where parts such as a suction valve and a intake manifold are densely disposed in the vicinity of the cylinder head, said fixing of the long nozzle injector has advantage of the high degree of fixing freedom.

In the above-described two-point support guide

system for the needle, it is necessary to finish (grind) a guide hole formed at the inner circumference of the nozzle body in the case where the stroke movement of the needle is guided on the inner circumference of the nozzle body. If the nozzle body is elongated, the guide surface is deeply positioned, thereby making machining difficult. In the meanwhile, even in the case where the guide surface is formed at the inner circumference near an opening of the nozzle body, followed by finishing, the inner circumference of the nozzle body requires a high grinding accuracy, thereby increasing a fabricating cost accordingly. Consequently, cost reduction is desired.

In addition, since the valve element collides with a valve seat during a valve closing operation in the electromagnetic fuel injector, the valve is accidentally opened by a bounce of the valve element, thereby inducing a fear of so-called secondary injection. Therefore, there are various demands for the technique for preventing such secondary injection, the configuration which contributes to assembling facilitation, in particular, automatic assembling, and the like.

#### SUMMARY OF THE INVENTION

An object of the present invention is to provide a fuel injector which can solve problems such as cost

reduction, centering accuracy (coaxial accuracy) and assembling facilitation of a fuel injector, simplicity of component parts, the degree of fixing freedom, and prevention of secondary injection.

The present invention has been proposed to attain the above-described object by way of a variety of modes. The gist of the present invention is as follows:

An electromagnetic fuel injector is basically configured such that an electromagnetic coil and a yoke are arranged around a fixed core, a nozzle body containing therein a needle with a valve element is fixed to the lower portion of the yoke, and the needle is urged toward a valve seat with application of the force of a return spring, and further, is provided with the following means:

(1) In order to achieve the cost reduction and centering accuracy (coaxial accuracy) in the two-point support guide system, a two-point support guide is composed as follow. In a fuel injector having the fuel swirler, a two-point support for slidably guiding a needle on the inner circumference of a non-magnetic cylindrical seal ring and the inner circumference of a fuel swirler during a valve stroke movement is composed by using the seal ring press-fitted and welded to the outer circumference of one end on a nozzle body side in a fixed core and the inner circumference of one end on the nozzle body side.

(2) In order to facilitate the assembling work of the fuel injector and simplify component parts, an electromagnetic coil and a yoke are inserted from above the fixed core, and thus, are disposed around the fixed core. Furthermore, the yoke is configured such that it can be coupled to the nozzle body in such a manner as to cover the outer periphery of an electromagnetic core. A terminal taking-out window for the electromagnetic coil is formed at a part of the upper portion of the yoke. The inner surface of the upper end of the yoke is pressed against the electromagnetic coil, thereby fixing the coil.

(4) Means described below are proposed to facilitate the assembling work of the fuel swirler and enhance the characteristics and responsiveness of fuel injection:

The fuel swirler is loosely fitted to the inner circumference of the nozzle body in such a manner as to be received by the receiving surface of the nozzle body. An orifice plate is press-fitted to the inner circumference in such a manner as to press the fuel swirler. Considering this from different points of view, the configuration is proposed that the fuel swirler is held between the receiving surface of the nozzle body and the orifice plate, and thus, an annular fuel passage is defined between the outer circumference of the fuel swirler and the inner circumference of the nozzle body, so that fuel flows in a

passage groove formed at the lower end of the fuel swirler via the annular fuel passage.

(5) In order to prevent any secondary injection, means described below are proposed as the composition capable of implementing a liquid damper structure for alleviating an impact occurring during a valve closing of the needle.

The inner circumference of the seal ring extending over the outer circumference of one end on the nozzle body side in the fixed core and the inner circumference of one end on the nozzle body side serves as a guide for the needle. The needle includes a hollow, cylindrical movable core. The outer circumference of the upper portion of the movable core is guided on the inner circumference of the seal ring. The fuel passage is secured between the outer circumference of the lower portion of the movable core and the inner circumference of the nozzle body. The fuel passage communicates with another fuel passage defined inside of the movable core upstream thereof via a through hole formed at the movable core.

(6) As means for preventing any collision (a bounce) of the needle against a valve seat or a stopper in order to prevent any secondary injection, there are proposed that an axially movable mass independently of the needle is interposed between the return spring and the needle, and

that a plate spring is interposed between the mass and the needle.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a vertical cross-sectional view showing a fuel injector in a preferred embodiment according to the present invention;

Fig. 2 illustrates the mounted state of the fuel injector;

Fig. 3 illustrates the assembling process of the fuel injector;

Fig. 4(a) is a top view showing a fuel swirler to be used in the present embodiment, Fig. 4(b) is a bottom view of the fuel swirler, and Fig. 4(c) is a vertical cross-sectional view of the fuel swirler; and

Fig. 5(a) is a plan view showing a damper plate (a plate spring) to be used in the present embodiment, and Fig. 5(b) is a cross-sectional view showing the damper plate.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

A best mode embodying the present invention will be described in reference to a preferred embodiment shown in Figs. 1 to 5.

As shown in Fig. 1, a hollow fixed core 1, an electromagnetic coil 2 and a yoke 4 are arranged from the

center toward the outer diameter in a fuel injector 100, and further, a needle 5 with a valve element is contained inside a nozzle body (also referred to as a nozzle holder) 18 fixed to the lower portion of the yoke 4, wherein the needle 5 is urged toward a valve seat 31 by the force of a return spring 7.

With respect to the basic movement of the fuel injector 100, when the electromagnetic coil 2 is energized, the yoke 4, the fixed core 1, a movable core 14 (i.e., a part of the needle 5) and the upper portion of the nozzle body 18 constitute a magnetic circuit, so that the needle 5 is attracted against the force of the return spring 7, thereby achieving a valve opening; in contrast, when the energization of the electromagnetic coil 2 is stopped, the needle 5 abuts against the valve seat 31 by the force of the return spring 7, thereby achieving a valve closing.

In the present embodiment, the lower end of the fixed core 1 functions as a stopper for receiving the needle 5 during the valve opening.

The fixed core 1 is formed into an elongated, hollow and slenderly cylindrical shape. The fixed core 1 and the nozzle body 18 are coupled to each other via a non-magnetic, cylindrical seal ring 8 extending over the outer circumference of one end on the nozzle body side of the fixed core 1 and the inner circumference of one end of the

nozzle body 18.

The seal ring 8 is ground with material such as SUS316, and is formed into a cylinder having a flange 8a at one end thereof. One end of the cylinder on a side opposite to the flange 8a is press-fitted and welded to one end of the outer circumference of the fixed core 1; on the other hand, the flange 8a is press-fitted and welded to an annular step (an annular groove) 18c formed at the inner edge of the upper end of the nozzle body 18. Such welding is performed over the entire coupling boundary of, for example, portions designated by reference characters (b) and (c) by laser welding in order to keep sealability.

Here, the annular step 18c is a part having the greatest inner diameter of the stepped inner circumference of the nozzle body 18.

An upper portion 18b of the nozzle body 18 has greatest inner and outer diameters in the nozzle body 1 in order to house therein the movable core 14a, described later, in such a manner as to allow a freely reciprocating movement (a stroke movement required for opening or closing a valve). A slender, long nozzle portion 18a extends from the lower portion.

In an injection system in which the fuel injector 100 is mounted directly in a cylinder head 106 of an engine 105, as shown in Fig. 2, the long nozzle portion 18a

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enables an injector body having a large diameter to be placed at a position apart from (i.e., a position without any interference with) a suction valve 101, a drive mechanism 102 for a suction/exhaust valve, a intake manifold 103 or the cylinder head 106 in the case where the suction valve 101, the drive mechanism 102, the intake manifold 103 and the like are mounted at a high density, with an attendant advantage of the higher degree of fixing freedom.

The upper portion (the large-diameter portion) 18b of the nozzle body 18 extends upward to a position at which a magnetic flux for attracting the movable core is allowed to pass when the electromagnetic coil 2 is energized, that is, to a position at which a part of the magnetic circuit is constituted. In view of this, the upper portion 18b of the nozzle body 18 also serves as a part of the yoke 4.

The upper end surface of the nozzle body 18 includes the above-described annular step 18c for allowing the flange 8a of the seal ring 8 to be press-fitted thereto while a step 18d to be press-fitted in a spigot joint manner to (i.e., in uneven engagement with) the yoke 4, and therefore, includes three stepped surfaces in total.

In the yoke 4, an opening at the lower end (i.e., one end facing the nozzle body 18) is formed slightly larger than the outer diameter of the electromagnetic coil

2 with a resin mold 3, and thus, is formed into a so-called drop-bottomed shape. At the lower end of the yoke is formed a step 4c to be press-fitted to the step 18d of the nozzle body 18 in the spigot joint manner.

In the yoke 4, an upper wall 4b (hereinafter referred to as a shoulder) is formed in such a manner as to cover the upper end of the resin mold 3 of the electromagnetic coil 2. At the center of the shoulder 4b, a core inserting hole 4a engageable with the outer circumference of the fixed core 1 is formed by drawing.

The yoke 4 configured as described above is disposed from above the fixed core 1. Furthermore, the yoke 4 is configured such that it can be press-fitted (coupled) to the annular step 18d of the nozzle body 18 in the spigot joint manner in such a manner as to cover the electromagnetic core 2 with the resin mold 3. At a part of the shoulder 4b of the yoke 4 is formed as a window 4d, through which a connector terminal 29 for the electromagnetic coil 3 can be inserted.

The electromagnetic coil 2 is received at the upper end surface of the nozzle body 18, and then, is pressed at the inner surface of the shoulder 4b of the yoke 4, to be thus fixed thereto.

The yoke 4 and the nozzle body 18 are annularly welded to each other at a jointed portion (a) of the press-

fitted portion (i.e., the spigot-jointed portion) therebetween, and further, the yoke 4 and the fixed core 1 are welded to each other at a position (d), thereby keeping the sealability.

The fixed core 1, the yoke 4, the needle 5 and the nozzle body 18 are made of, for example, a stainless-based magnetic material (i.e., electromagnetic stainless) in order to constitute the magnetic circuit of the electromagnetic coil 2. Its machining mode will be described later.

At the lower end (i.e., the tip) of the nozzle body 18 are disposed an orifice plate 19 and a fuel swirler (hereinafter simply referred to as a swirler) 21, wherein these component parts 18, 19 and 21 are formed of separate members.

The orifice plate 19 is formed by, for example, a stainless-based disk-like chip, and is provided at the center thereof with an injection orifice (an orifice) 20, upstream of which the valve seat 31 is formed. The orifice plate 19 is press-fitted to the inner circumference 18f of the lower end of the nozzle body 18.

In the meantime, the swirler 21 is loosely fitted to the inner circumference of the lower end of the nozzle body 18, and is made of a sintered alloy such as SUS416.

The swirler 21 is formed by a substantially disk-

like chip, and is provided at the center thereof with a center hole (a guide) 25 for slidably guiding the tip (the valve element) of the needle 5 and at the upper surface thereof with a guide groove 24 for guiding fuel toward the outer circumference, as shown in Figs. 4(a) and 4(c).

Moreover, as shown in Figs. 4(b) and 4(c), an annular step (an annular passage) 23 is formed at the peripheral edge of the lower surface of the swirler 21, and further, a plurality of, for example, six passage grooves 26 for forming a fuel swirl are arranged between the annular passage 23 and the center hole 25. The passage groove 26 is formed in substantially the tangential direction from the outer diameter of the swirler 21 to the inner diameter thereof, so as to generate swirling force in the fuel injected from the passage groove 26 toward the lower end of the center hole 25.

The annular step 23 is formed because it need serve as a fuel sump. Moreover, a plurality of chamfers 27 are formed at the outer circumference of the swirler 21. The chamfers 27 are referred to in machining the grooves 24 and 26 and the like.

At the tip (one end on the fuel injection side) of the nozzle body 18 is formed the inner circumference (the stepped inner circumference) 18f with a receiving surface 18e for receiving the swirler 21 and the orifice plate 19.

The swirler 21 is received at the receiving surface 18e of the nozzle body 18, to be loosely fitted to the inner circumference of the nozzle body. On the other hand, the orifice plate 19 is press-fitted and welded to the inner circumference in such a manner as to press the swirler 21.

The swirler 21 and the orifice plate 19 are disposed in the above-described manner, so that the swirler 21 can be held between the receiving surface 18e and the orifice plate 19, and further, an annular fuel passage 22 is defined between the outer circumference of the swirler 21 and the inner circumference of the tip of the nozzle body 18. The annular fuel passage 22 can be sufficiently secured as a fuel passage without any chamber 27. Via these annular fuel passages 22 and 23, the fuel can flow into the groove 26 for forming a swirl in the swirler 21.

The upper surface of the swirler 21 is configured such that the fuel guide groove 24 is formed for the purpose of the press-contact with the receiving surface 18e formed in the nozzle body 18, so that the fuel staying upstream of the swirler can flow into the annular fuel passage 22 around the swirler 21 via the groove 24. The groove 24 may be formed on a side of the receiving surface 18e of the nozzle body other than the upper end surface of the swirler 21.

That is, whichever the swirler 21 and the nozzle

body 18 may be, it is sufficient that a passage groove for guiding the fuel around the swirler is defined between the upper end surface of the swirler and the receiving surface of the nozzle body receiving the former.

Incidentally, a part of the orifice plate 19 intrudes into the groove 26 formed at one end surface of the swirler 21 to such an extent that the part cannot interfere with the flow in the passage groove, and thus, secures the function of a detent of the swirler 21.

For example, if the hardness of the swirler 21 is made to be greater than that of the orifice plate 19, a part of the orifice plate 19 can bite the groove 26 when the orifice plate 19 is press-fitted, thereby securing the detent of the swirler 21 and preventing any misalignment of the swirler 21.

The needle 5 includes a valve rod (i.e., a needle) 16 and the hollow, cylindrical movable core 14 having an outer diameter greater than that of the valve rod 16. The valve rod 16 and the movable core 14 are constituted of separate members, and are integrally coupled to each other by press-fitting and welding the valve rod 16 to one end of the movable core 14.

A part of each of the movable core 14 and the valve rod 16 serves as a guide surface on a movable side. Here, one part 14a at the outer peripheral surface of the movable

core 14 is slidably guided on the inner circumference of the seal ring 8 during a stroke movement at the time of the valve opening or closing, and then, the peripheral surface near the tip of the valve rod 16 is slidably guided to the center hole 25 of the swirler 21, thereby constituting a so-called two-point support guide system.

In the present embodiment, the diameter of the outer circumference 14a of the upper portion of the movable core 14 is made to be greater than that of an outer circumference 14b of the lower portion thereof, so that the outer circumference 14a of the upper portion is slidably guided at the inner circumferential surface of the seal ring 8; in the meantime, the diameter of the outer circumference 14b of the lower portion is made to be smaller than that of the outer circumference 14a of the upper portion, so that a sufficient fuel passage 13 can be secured between the outer circumference 14b of the lower portion and the inner circumference of the nozzle body 18.

The fuel passage 13 and the inside of the movable core 14 serving as an upstream passage 12 communicate with each other via a plurality of through holes (i.e., orifices) 15 formed on a core wall of the outer circumference 14b of the lower portion.

A step 14c is formed at the inner surface of the upper portion of the movable core 14, and is provided with

an annular plate spring (i.e., a damper plate) 50.

As shown in Fig. 5, the plate spring 50 is formed into an annular shape, and an inside portion designated by reference numeral 51 is punched. A plurality of elastic pieces 52 projecting inward are formed by punching in arrangement at equal intervals in the circumferential direction.

The elastic pieces 52 in the plate spring 50 receive one end of a cylindrical movable mass (i.e., a weight) 9, which is, for example, a carbon steel forging product.

The movable mass 9 is positioned over one end of the inner circumference of the fixed core 1 and one end of the inner circumference of the movable core 14. A hollow hole 11 of the fixed core 1 serves as a fuel passage. Inside the hollow hole 11 are contained the movable mass 9, the return spring 7 and a spring presser 6 in order from under. A filter 30 is disposed at the upper end of the hollow hole 11.

The spring presser 6 is fixed by caulking a peripheral portion 10 of the fixed core 1.

The movable mass 9 is interposed between the return spring 7 and the needle 5 (the movable core 14) in such a manner as to be freely moved in an axial direction independently of the needle 5. In order to ensure the independent movability, the spring plate 50 is interposed

between the movable mass 9 and the needle 5, so that the elastic pieces 52 of the spring plate 50 receive the movable mass 9.

In this manner, the movable mass 9 fulfills a damper function of suppressing a bounce of the needle 5 during a valve closing movement owing to its independence of the needle 5 with a valve. This damper function produces a remarkably effective result, the principle of which is considered as follows: namely, it is considered that although the needle 5 is about to bounce when the needle 5 collides against the valve seat 31 by the force of the return spring 7 during the valve closing movement, the inertia of the movable mass 9 and the resilient deformation of the spring plate 50 absorb kinetic energy of the bounce at that time, thereby attenuating the bounce.

A connector mold (i.e., a resin mold) 27 is formed around a portion projecting from the yoke 4, of the fixed core 1.

Subsequently, a description will be given of the assembly and the machining mode of main component parts in the present embodiment.

As shown in Fig. 3, in assembling the fuel injector in the present embodiment, the component parts are inserted from above in reference to the nozzle body 18 except for resin molding with the connector mold.

Pre-processes before assembling the component parts will be explained below.

The yoke 4 is a pressed and cut product. The nozzle body 18 is a cold forged product through not cutting but lathing. The swirler 21 is a sintered product through cutting. The orifice plate 19 is lathed, and further, is quenched in order to enhance its hardness. The valve seat 31 and the orifice 20 are ground and end-lapped.

The valve rod 16 is quenched, and the movable core 14 is annealed. Thereafter, these component parts 14 and 16 are integrally coupled to each other by press-fitting and welding, thus constituting the needle 5.

The outer circumference of the needle 5 is ground. The outer peripheral surface (the movable guide surface) 14a at the upper portion and the end surface (the movable stopper surface) in the movable core 14 are subjected to hard plating.

The fixed core 1 is a cold forged product through lathing and annealing, and further, the tip thereof serving as a stopper surface with respect to the needle is subjected to hard plating. The seal ring 8 is lathed, and then, is press-fitted and welded to one end of the outer circumference of the fixed core 1 after plating.

The swirler 21 is loosely fitted to the nozzle body 18 by the use of a centering jig, and thereafter, the

orifice plate 19 is press-fitted and welded to the nozzle body 18.

The above pre-processed component parts are assembled in the following procedure.

The needle 5 having the plate spring 50 disposed therein is inserted into the nozzle body 18 from above, and then, the flange at one end of the seal ring 8 fixed to the fixed core 1 with the seal ring 8 is press-fitted and welded to the nozzle body 18, so that the fixed core 1 and the nozzle body 18 are integrally coupled to each other. Before the integral coupling, the step of the nozzle body 18 serving as the coupled (press-fitted) portion is measured, and further, the step of the flange of the seal ring 8 on the side of the fixed core 1 is measured. The fixed core 1 and the nozzle body 18 through the measurement examination are integrally coupled to each other. Consequently, the coaxial accuracy can be ensured.

Thereafter, the assembly of the electromagnetic coil 2 and the yoke 4 are fitted into the fixed core 1 from above. The yoke 4 is also coupled to the nozzle body 18 by press-fitting and welding. And then, the connector mold 27 is formed.

The above finished products constitute the magnetic circuit, described already, when the electromagnetic coil 2 is energized (excited), so that the needle 5 is attracted

until it abuts on one end of the fixed core 1 against the force of the return spring 7, thereby achieving the valve opening movement. At the time of the valve opening, pressurized fuel is injected with a swirl from the injection orifice 20 via the swirler 21 through the filter 30, the fuel passages 11 and 12, the orifices 15 and the passages 13 and 17.

The present embodiment can produce the following effects:

(1) When the electromagnetic coil 2 is de-energized, the needle 5 is moved in the closing direction by a load accumulated in the return spring 7, and then, abuts against the valve seat 31. At this time, the damper function of the movable mass 9 and the plate spring 50, as described already, suppresses the bounce of the valve element 16, thereby effectively preventing any secondary injection.

(2) Furthermore, since the entire outer circumference 14a of the upper portion of the movable core is slidably guided on the inner circumference of the seal ring 18 during the valve opening/closing movement, the fuel is hardly relieved to the slidably guiding surface, and consequently, all the fuel flows between the passage 12 inside of the movable core 14 and the passage 13 outside thereof via the orifices 15. Therefore, the liquid damper function is appropriately fulfilled between the lower end

surface (the stopper) of the fixed core 1 and the end surface of the movable core 14, thus contributing to alleviation of an impact of the needle 5 with respect to the stopper and suppression of the bounce of the needle 5 at the time of the valve closing.

(3) The needle 5 is supported and guided at the two points on the inner circumference of the swirler 21 and the inner circumference of the seal ring 8. Consequently, the nozzle body per se need not be equipped with a guide function, unlike the prior art. Therefore, it becomes unnecessary to grind the nozzle body with high accuracy while the seal ring, which is easy to be lathed, can ensure the highly accurate guide function. Thus, the needle can be supported and guided at the two points at a reduced cost even in the case of a long nozzle injector.

(4) The prior art has experienced the problem that the coaxial accuracy is enhanced while eliminating a troublesome grinding work (the guide formation) with respect to the inner circumference of the nozzle body 18. However, through the above-described assembling process, the fixed core 1 and the nozzle body 18 can be integrally coupled to each other by press-fitting and welding the seal ring 18 with relative facilitation while the high coaxial accuracy is maintained, thereby streamlining the assembling work and reducing the cost.

(5) Moreover, as shown in Fig. 3, all of the component parts except the connector mold can be assembled in the same direction in reference to the nozzle body 18, thus contributing to the facilitation and automation of the work.

(6) Since the swirler 21 is loosely fitted while is fixed to the orifice plate 19, the swirler 21 can be prevented from being shifted, and further, the entire circumference of the swirler 21 constitutes the annular fuel passage, thereby reducing passage resistance, facilitating the relief of bubbles, which have been liable to remain at the lower end of the swirler 21, and achieving the smooth fuel injection.

(7) Although the swirler 21 is loosely fitted, it is free from physical restriction of other members until the centering jig is set in fitting, thereby offering the degree of centering freedom. Furthermore, even in the case where the orifice plate 19 is welded, thermal expansion caused by the resultant welding heat also is absorbed at the clearance defined around the swirler 21, thus preventing any generation of thermal deformation in the swirler 21.

(8) The annular passage 23 defined by the annular step is formed upstream of the groove 24 for forming the fuel swirl at the lower end surface of the swirler 21, and

thus, functions as the fuel sump. Consequently, it is possible to enhance the injection responsiveness at the time of the fuel injection.

#### Industrial Applicability

As described above, the present invention can solve the problems so as to reduce the cost of the fuel injector, enhance the centering accuracy (the coaxial accuracy), facilitate the assembling work, simplify the component parts, offer the degree of fixing freedom, prevent any secondary injection and the like.

## WHAT IS CLAIMED IS:

1. An electromagnetic fuel injector, in which a hollow fixed core, an electromagnetic coil and a yoke are arranged from the center toward the outer diameter, a needle with a valve element is contained in a nozzle body fixed to the lower portion of the yoke, and the needle is urged toward a valve seat by the force of a return spring, the electromagnetic fuel injector characterized in that:

a fuel swirler positioned upstream of an injection orifice is disposed at the tip of the nozzle body, the fixed core and the nozzle body being coupled to each other via a non-magnetic cylindrical seal ring press-fitted and welded to the outer circumference of one end on the nozzle body side of the fixed core and the inner circumference of one end of the nozzle body; and

the inner circumference of the fuel swirler and the inner circumference of the seal ring function as a guide for slidably guiding a stroke movement of the needle.

2. An electromagnetic fuel injector according to claim 1, characterized in that the yoke and the nozzle body also are coupled to each other by press-fitting and welding.

3. An electromagnetic fuel injector according to claim 2, characterized in that the seal ring has a flange at one end thereof, one end of a cylindrical portion on a side opposite to the flange is press-fitted and welded to

one end of the outer circumference of the fixed core, while the flange is press-fitted and welded to an annular step formed at the upper end of the nozzle body; and

the yoke and the nozzle body are press-fitted in a spigot joint manner, followed by welding.

4. An electromagnetic fuel injector, in which an electromagnetic coil and a yoke are arranged around a hollow, cylindrical fixed core, a nozzle body containing therein a needle with a valve element is fixed to the lower portion of the yoke, and the needle is urged toward a valve seat by the force of a return spring, the electromagnetic fuel injector characterized in that:

the electromagnetic coil and the yoke are configured in such a manner as to be fitted around the fixed core from above the fixed core;

the yoke can be coupled to the upper end of the nozzle body in such a manner as to cover the electromagnetic core;

a terminal taking-out window for the electromagnetic coil is formed at a part of the upper portion of the yoke; and

the inner surface of the upper end of the yoke presses the electromagnetic coil, thus fixing the coil.

5. An electromagnetic fuel injector according to claim 4, characterized in that a bore of the upper end of

the yoke is drawn, and the inner circumference of the upper end is coupled to the outer circumference of the fixed core by any of welding, press-fitting and caulking.

6. An electromagnetic fuel injector, in which an electromagnetic coil and a yoke are arranged around a fixed core, a nozzle body containing therein a needle with a valve element is fixed to the lower portion of the yoke, and the needle is urged toward a valve seat by the force of a return spring, the electromagnetic fuel injector characterized in that:

the fixed core and the nozzle body are coupled to each other via a non-magnetic cylindrical seal ring extending over the outer circumference of one end of the fixed core and the inner circumference of one end of the nozzle body;

the inner circumference of the seal ring serves as a guide for the needle;

the needle has a hollow, cylindrical movable core, the outer circumference of the upper portion of the movable core being slidably guided on the inner circumference of the seal ring during a stroke movement, a fuel passage being secured between the outer circumference of the lower portion and the inner circumference of the nozzle body, and the fuel passage communicating with another fuel passage defined inside of the movable core via a through hole

7. An electromagnetic fuel injector according to claim 6, characterized in that the outer circumference of the lower portion of the movable core is made to be smaller in diameter than the outer circumference of the upper portion thereof so as to enlarge the fuel passage defined between the outer circumference of the lower portion and the inner circumference of the nozzle body, the through hole being formed on a core wall on which the outer circumference of the lower portion is positioned.

a nozzle body, an orifice plate having an injection orifice and a fuel swirler are formed of separate members;

the fuel swirler is loosely fitted to the inner circumference of the nozzle body in such a manner as to be received at the receiving surface of the nozzle body; and

9. An electromagnetic fuel injector characterized in

that:

a nozzle body, an orifice plate having an injection orifice and a fuel swirler are formed of separate members;

an inner circumference having a receiving surface for disposing the fuel swirler and the orifice plate is formed at one end on a fuel injection side of the nozzle body; and

the fuel swirler is held between the receiving surface of the nozzle body and the orifice plate, thus defining an annular fuel passage between the outer circumference of the fuel swirler and the inner circumference of the nozzle body, so that fuel flows into a passage groove formed at the lower end surface of the fuel swirler via the annular fuel passage.

10. An electromagnetic fuel injector according to claim 8 or claim 9, characterized in that a guide groove for guiding the fuel to the outer circumference of the fuel swirler is formed between the upper end surface of the fuel swirler and the receiving surface of the nozzle body for receiving the upper end surface of the fuel swirler.

11. An electromagnetic fuel injector according to claim 10, characterized in that the guide groove is formed at the upper end surface of the fuel swirler and/or the receiving surface of the nozzle body.

12. An electromagnetic fuel injector according to

claims 8 , characterized in that the hardness of the fuel swirler is greater than that of the orifice plate.

13. An electromagnetic fuel injector according to claims 8, characterized in that a part of the orifice plate intrudes into the passage groove for generating a swirl, formed at the lower end surface of the fuel swirler.

14. An electromagnetic fuel injector in which a fuel swirler is disposed upstream of a fuel injection orifice, the electromagnetic fuel injector characterized in that:

a passage groove for generating a swirl and an annular passage communicating with the passage groove on an upstream side are formed at the lower end surface of the fuel swirler.

15. An electromagnetic fuel injector according to claim 14, characterized in that the annular passage is defined by forming an annular step at the peripheral edge of one end surface of the fuel swirler.

16. An electromagnetic fuel injector, in which a hollow fixed core, an electromagnetic coil and a yoke are arranged from the center toward the outer diameter, a needle with a valve element is contained in a nozzle body fixed to the lower portion of the yoke, and the needle is urged toward a valve seat with application of the force of a return spring, the electromagnetic fuel injector characterized in that:

a mass movable in an axial direction independently of the needle is interposed between the return spring and the needle.

17. An electromagnetic fuel injector, in which a hollow fixed core, an electromagnetic coil and a yoke are arranged from the center toward the outer diameter, a needle having a valve element is contained in a nozzle body fixed to the lower portion of the yoke, and the needle is urged toward a valve seat by the force of a return spring, the electromagnetic fuel injector characterized in that:

a mass movable in an axial direction independently of the needle is interposed between the return spring and the needle, and a plate spring is interposed between the mass and the needle.

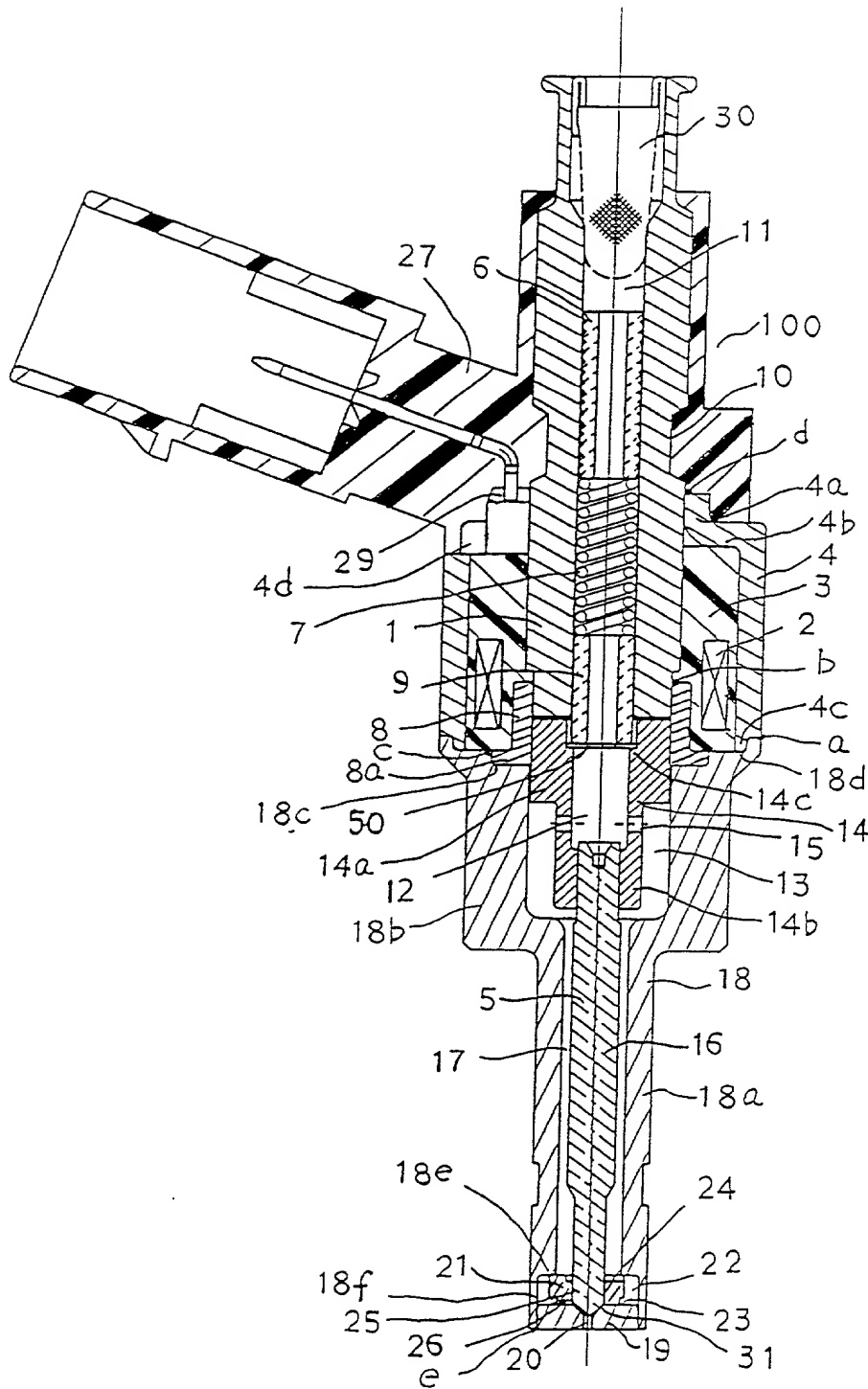
## ABSTRACT

A fuel swirler positioned upstream of an injection orifice is disposed at the tip of a nozzle body in a fuel injector, in which the fixed core and the nozzle body are coupled to each other via a non-magnetic cylindrical seal ring press-fitted and welded to the outer circumference of one end on the nozzle body side of the fixed core and the inner circumference of one end of the nozzle body.

The inner circumference of the fuel swirler and the inner circumference of the seal ring function serve as a guide for slidably guiding a stroke movement of the needle. The fuel swirler is held between the receiving surface of the nozzle body and the orifice plate, thus defining an annular fuel passage between the outer circumference of the fuel swirler and the inner circumference of the nozzle body, so that fuel flows into a passage groove formed at the lower end surface of the fuel swirler via the annular fuel passage.

A mass movable in an axial direction independently of the needle is interposed between the return spring and the needle, and a plate spring is interposed between the mass and the needle.

FIG. 1



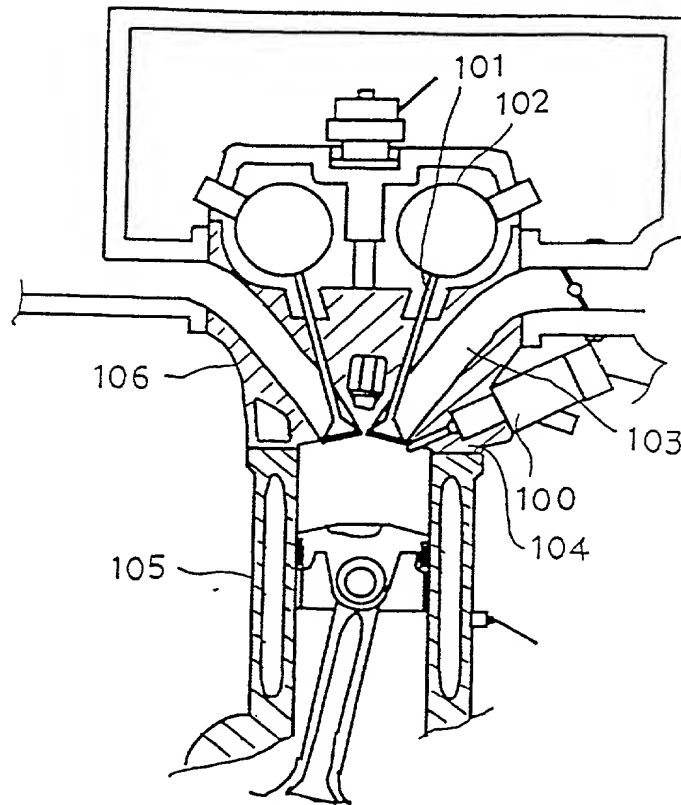
*FIG. 2*

FIG. 3

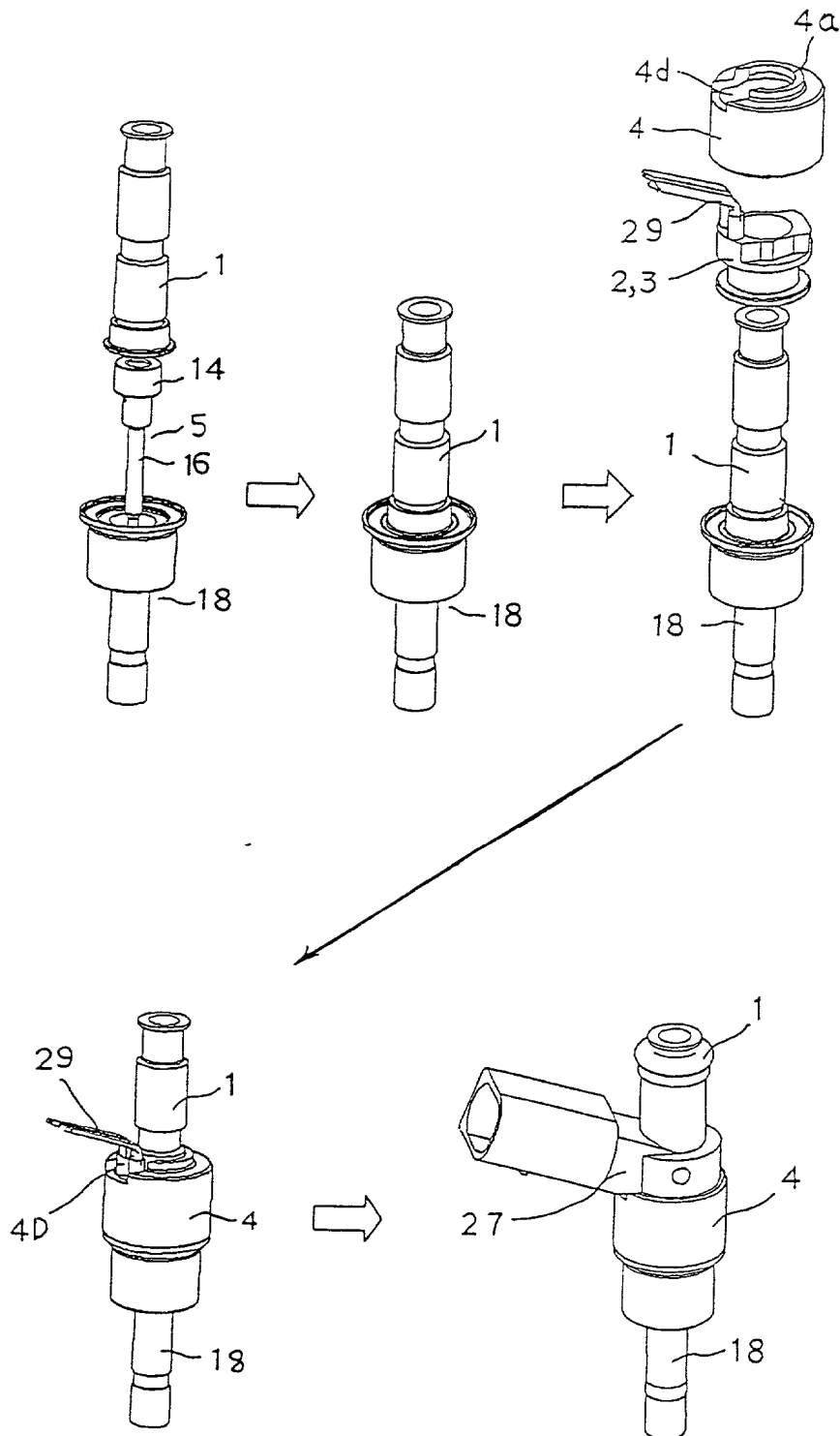


FIG. 4a

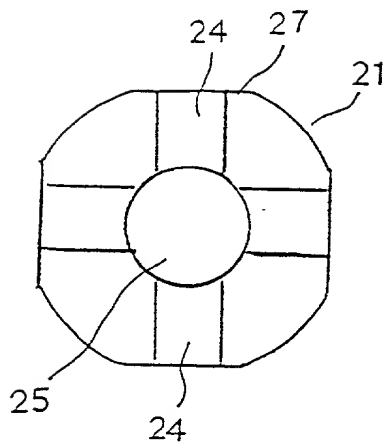


FIG. 4b

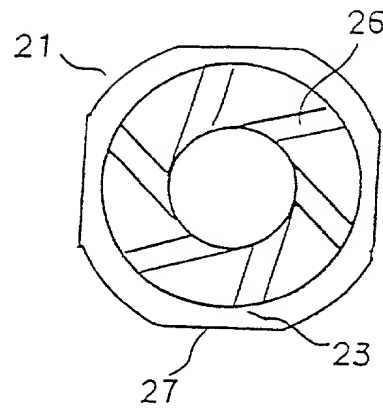


FIG. 4c

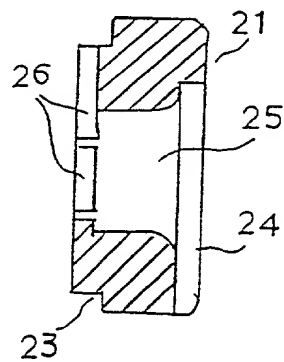


FIG. 5a

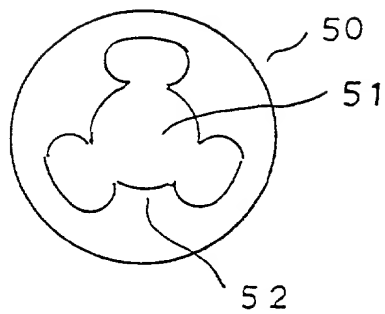
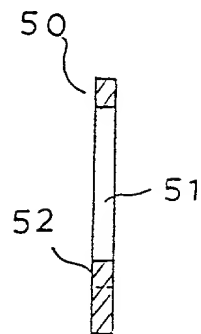


FIG. 5b



## Declaration and Power of Attorney For Patent Application

## 特許出願宣言書及び委任状

## Japanese Language Declaration

## 日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Electromagnetic Fuel Injector

上記発明の明細書（下記の欄で×印がついていない場合は、本書に添付）は、

The specification of which is attached hereto unless the following box is checked:

☐ 月 日に提出され、米国出願番号または特許協定条約国際出願番号を \_\_\_\_\_ とし、  
(該当する場合) \_\_\_\_\_ に訂正されました。

☒ was filed on January 26, 2000  
as United States Application Number or  
PCT International Application Number  
PCT/JP00/00374 and was amended on  
\_\_\_\_\_ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されたとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

## Japanese Language Declaration

## (日本語宣言書)

私は、米国法典第35編119条 (a) - (d) 項又は365条 (b) 項に基づき下記の、米国以外の国の少なくとも一カ国を指定している特許協力条約365 (a) 項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示している。

## Prior Foreign Application(s)

外国での先行出願

(Number) (番号)	(Country) (国名)
(Number) (番号)	(Country) (国名)

私は、第35編米国法典119条 (e) 項に基づいて下記の米国外特許出願規定に記載された権利をここに主張いたします。

(Application No.) (出願番号)	(Filing Date) (出願日)
-----------------------------	------------------------

私は、下記の米国法典第35編120条に基づいて下記の米国外特許出願に記載された権利、又は米国を指定している特許協力条約365条 (c) に基づく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国外特許出願に開示されていない限り、その先行米国外出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

(Application No.) (出願番号)	(Filing Date) (出願日)
(Application No.) (出願番号)	(Filing Date) (出願日)

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I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Priority Not Claimed

優先権主張なし

(Day/Month/Year Filed) (出願年月日)	<input type="checkbox"/>
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(Application No.) (出願番号)	(Filing Date) (出願日)
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I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of application.

(Status: Patented, Pending, Abandoned) (現況: 特許許可済、係属中、放棄済)
(Status: Patented, Pending, Abandoned) (現況: 特許許可済、係属中、放棄済)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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### Japanese Language Declaration (日本語宣言書)

委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。(弁護士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

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Martin Fleit, Reg. No. 16,900; Herbert I. Cantor, Reg. No. 24,392; James F. McKeown, Reg. No. 25,406; Donald D. Evenson, Reg. No. 26,160; Joseph D. Evans, Reg. No. 26,269; Gary R. Edwards, Reg. No. 31,824; Jeffrey D. Sanok, Reg. No. 32,169; Richard R. Diefendorf, Reg. No. 32,390; and Paul A. Schnose, Reg. No. 39,361

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発明者の署名	日付	Inventor's signature <u>Kiyotaka Ogura</u>	Date <u>02/15/2001</u>
住所	Residence <u>Hitachinaka, Japan</u>		<u>JPX</u>
国籍	Citizenship <u>Japan</u>		
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg., 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan		

(第二以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for second and subsequent joint inventors.)

第二共同発明者	Full name of second joint inventor, if any <u>Atsushi SEKINE</u> 2-W
第二共同発明者の署名 日付	Second inventor's signature Date <u>Atsushi Sekine</u> 02/16/2001
住所	Residence <u>Hitachinaka, Japan</u> JPX
国籍	Citizenship Japan
私書箱	Post Office Address c/o HITACHI CAR ENGINEERING CO., LTD. 2477, Takaba, Hitachinaka-shi, Ibaraki 312-0062, Japan
第三共同発明者	Full name of third joint inventor, if any <u>Eiichi KUBOTA</u> 3-W
第三共同発明者の署名 日付	Third inventor's signature Date <u>Eiichi Kubota</u> 02/09/2001
住所	Residence <u>Niihari-gun, Japan</u> JPX
国籍	Citizenship Japan
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg., 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan
第四共同発明者	Full name of fourth joint inventor, if any <u>Masafumi NAKANQ</u> 4-W
第四共同発明者の署名 日付	Fourth inventor's signature Date <u>Masafumi Nakano</u> 02/09/2001
住所	Residence <u>Hitachi, Japan</u> JPX
国籍	Citizenship Japan
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第五共同発明者	Full name of fifth joint inventor, if any <u>Keiichi URAKI</u> 5-W
第五共同発明者の署名 日付	Fifth inventor's signature Date <u>Keiichi Uraki</u> 02/09/2001
住所	Residence <u>Hitachinaka, Japan</u> JPX
国籍	Citizenship Japan
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg., 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan

(第六以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for sixth and subsequent joint inventors.)

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第六共同発明者	Full name of sixth joint inventor, if any <u>Noriyuki MAEKAWA</u>	
第六共同発明者の署名	日付	Sixth inventor's signature Date <u>Noriyuki Maekawa</u> <u>02/15/2001</u>
住所	Residence <u>Niihari-gun, Japan</u>	
国籍	Citizenship <u>Japan</u>	
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg., 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan	
第七共同発明者	Full name of seventh joint inventor, if any <u>Mizuho YOKOYAMA</u>	
第七共同発明者の署名	日付	Seventh inventor's signature Date <u>Mizuho Yokoyama</u> <u>02/09/2001</u>
住所	Residence <u>Hitachinaka, Japan</u>	
国籍	Citizenship <u>Japan</u>	
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg., 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan	
第八共同発明者	Full name of eighth joint inventor, if any <u>Yoshiyuki TANABE</u>	
第八共同発明者の署名	日付	Eighth inventor's signature Date <u>Yoshiyuki Tanabe</u> <u>02/26/2001</u>
住所	Residence <u>Hitachinaka, Japan</u>	
国籍	Citizenship <u>Japan</u>	
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg., 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan	
第九共同発明者	Full name of ninth joint inventor, if any <u>Hiromasa KUBO</u>	
第九共同発明者の署名	日付	Ninth inventor's signature Date <u>Hiromasa Kubo</u> <u>02/15/2001</u>
住所	Residence <u>Yokohama, Japan</u>	
国籍	Citizenship <u>Japan</u>	
私書箱	Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg., 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan	

(第十以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for tenth and subsequent joint inventors.)

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第十共同発明者	Full name of tenth joint inventor, if any	
	Tooru ISHIKAWA	
第十共同発明者の署名	日付	Sixth inventor's signature Date
		Tooru Ishikawa X 02/16/2007
住所	Residence	
	Kitaibaraki, Japan	
国籍	Citizenship	
	Japan	
私書箱	Post Office Address	
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第十一共同発明者	Full name of eleventh joint inventor, if any	
第十一共同発明者の署名	日付	Seventh inventor's signature Date
住所	Residence	
国籍	Citizenship	
私書箱	Post Office Address	
第十二共同発明者	Full name of twelfth joint inventor, if any	
第十二共同発明者の署名	日付	Eighth inventor's signature Date
住所	Residence	
国籍	Citizenship	
私書箱	Post Office Address	
第十三共同発明者	Full name of thirteenth joint inventor, if any	
第十三共同発明者の署名	日付	Ninth inventor's signature Date
住所	Residence	
国籍	Citizenship	
私書箱	Post Office Address	

(第十四以降の共同発明者についても同様に記載し、署名を  
すること)(Supply similar information and signature for fourteenth and  
subsequent joint inventors.)